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ScienceDirect
Procedia Computer Science 91 (2016) 211 – 220
Procedia Computer Science

Information Technology and Quantitative Management (ITQM 2016)

# Exploring Potential Users of Patents for Technology Transfer: Utilizing Patent Citation Data

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**Abstract**

The purpose of this study is to examine whether potential users of technology can be identified by patent citation analysis. Previous research relied on patent's keywords, and as a consequence it was difficult to implement in practice where organizations retain huge number of patents to transfer. In this study, we attempt to use IPC instead of keywords. Our approach is to identify dominant IPC and sub-classes of an organization by applying co-classification analysis, and explore firms that cited the patents in the dominant IPC. Our view is that the organizations explored in this process can be potential users of technology. To verify our view, we examined the patents and technology transfer cases of K Research Institute's Division A. The results show that our view was right only for the field with co-classification of B01J and C07C, and it was not possible to confirm our argument for other classes. We suppose that the reasons may stem from technological characteristics and firm size effect. Therefore, we suggest that there should be further research considering technological characteristics and firm size.


Peer-review under responsibility of the Organizing Committee of ITQM 2016

Keywords: Technology Transfer; Patent Citation; Co-Classification; Path-Dependence; Potential User

## 1. Background

Recognizing the strategic importance of science and technology in global economy, firms, organizations, and national governments have put emphasis on R&D during the last a few decades. Countries such as Israel, Japan, and Finland spend over 3% of GDP on research and development activities, and Korea in 2014 topped in this field as its R&D expenditure touched 4.29% of GDP. The overall amount of R&D investment also

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Peer-review under responsibility of the Organizing Committee of ITQM 2016
doi:10.1016/j.procs.2016.07.059

increased rapidly over to 60 billion dollars. As the investment increased, the performance of Korean firms, research institutes, and universities has increased dramatically.

However, whilst the amount of technologies developed increased, the use and commercialization of technologies are still unsatisfactory. For instance, Korea's 24 public research institutes produced 9,656 patent applications in 2014, but the number of technology transfer in the same year was only 1,557. According to a government report[1], about 83.9% of patents are left unused despite successful application.

Until now, a number of studies have addressed the issue of technology transfer. Yang and Kim[2] argue that the difficulties in technology evaluation, lack of experts or dedicated teams for technology transfer, insufficient information about technology user firm and the firms' future strategies. KIBO[3] mentions that the information asymmetry between users and suppliers are the major sources of difficulties in technology transfer. Especially, they argue that the difficulties in identifying user of technology are major challenge in technology transfer. Even in the US, estimating market demand for specific technology is one of the main hurdles for US Federal Research Institutes' technology transfer[4]. Therefore, identifying the needs and potential users of technologies may be critical issue for successful technology transfer.

## 2. Previous Literature and Our Method

There are a number of approaches to identify potential users of technologies. Firstly, potential users can be found by survey. For instance, Lee et al.[5] identified SME's technological needs for IT products by conducting a survey, and many other studies also rely on survey. Secondly, there have been attempts to match between technology fields and industries. OECD constructed technology-industry concordance table[6], and Europe also attempted similar approach[7]. A Korean study[8] linked International Patent Class(IPC) with Korean Standard Industry Classifications, and utilized the result for identifying technology users. Thirdly, there is an approach of text-mining techniques. For instance, Seo et al [9] identified potential use of patents, and matched the uses with company names by text-mining.

However, the approaches above have some limitations. Survey sheets are randomly distributed, so respondents may be limited, and response rate may be low. For this reason, some significant or critical user needs may be omitted. In the case of concordance table, it is questionable whether industrial and technological evolution can be well reflected in the method. Lastly, text-mining techniques used by [9] is too time-consuming, therefore it is lacking practical utility.

For this reason, Seok et al.[10] suggested patent citation network analysis for technology transfer. The logic of their argument is as following. Technology citation is basically past information, so it may not be direct measure for present or future technological needs. However, it should be considered that technological progresses are characterized by technological paradigms, trajectories, and path dependencies[11, 12], and patent citation information can be used as proxy for path dependencies[13]. Then a firm that cited a patent in the past may still be in need of same sorts of technologies.

Seok et al.'s approach was much simpler to use, and their method was directly used for a research institute's technology marketing (according to an interview with one of the authors). However, the problem of their method is that it relies on keyword based search. It can be powerfully used when it is used for a single patent, but it is hard to implement at large organizational level. While large research organizations such as public research institutes usually retain a huge number of patents, the method requires keyword search for each patent. This makes the method still messy to implement in large organizations.

Therefore we suggest using patent class (e.g. IPC) instead of keywords. If an IPC can represent the overall technologies of an organization, taking the IPC instead of a huge number of keywords may make matters much simpler. However, just a single IPC may be too broad to identify a technology field. For this reason, we also suggest to use co-classifications to narrow the scope of technologies. Patents in many cases have multiple IPCs, so the patents characteristics can be more precisely identified by using co-classes of IPCs.

Our approach is as following. Firstly, an IPC that represent an organizations overall technological fields will be identified. (The IPC representing the organization will be called dominant IPC). We draw all the IPCs from the patents of an organization, and perform a co-classification analysis. This analysis will show what IPC is in the core of the organizations technologies. Secondly, we will examine what other IPCs are linked with the dominant IPC. The co-classifications of a dominant IPC and a sub-IPC may give us a more detailed picture of the technologies of the organization. Thirdly, we search patents which citing the patents in the co-classifications, and explore the names of applicants. The applicants are those cited the patents of the organization in the past. Considering path dependency, they may be still in need of technologies in the same (or similar) fields of technologies. Then we can regard these applicants as potential users of technology.

In the next section, we examine the patents and technology transfer cases of K Research Institute's Division A during 2004-2013 to verify this approach. K Research Institute is a government funded research lab specializing in chemistry. Among its 4 research divisions, we chose Division A. There are 2 reasons for this choice. Firstly, the division has compiled more patents than others, and the number of technology transfer and commercialization is highest in the K institute. The Division A has 198 patents and transferred its technologies to 82 companies, whilst other divisions have 65-95 patents and transferred technologies to 29-41 companies. Secondly, the patents and technologies of this division are expected to be good cases. As this division concentrates on processes while others on medical technologies and new materials, technological life-cycle may be longer and technological environments can be more stable than others. Therefore, path-dependency can be more clearly operate than in other divisions.

## 3. The Case of K Research Institute

### 3.1. *Dominant IPC of the Division A's Patents*

We collected IPCs in the patents applied by the Division A of K Research Institute, and counted the frequency of occurrence. The frequency is shown in the Table 1 below. According to the table, B01J is the most frequently appearing code. This means that the patents of the division are mostly about "chemical or physical processes".

Table 1. Frequency of IPC

| IPC | Frequency | IPC | Frequency |
|---|---|---|---|
| B01J | 61 | C09B | 2 |
| C07C | 39 | G02C | 2 |
| B01D | 16 | H01L | 2 |
| C02F | 16 | A01N | 1 |
| C08J | 16 | A01P | 1 |
| C01B | 14 | A61P | 1 |
| C08G | 11 | B22F | 1 |
| B82Y | 9 | C03B | 1 |
| C10G | 8 | C07F | 1 |
| C07D | 7 | C08F | 1 |
| C08L | 7 | C08K | 1 |
| B82B | 6 | C09C | 1 |

| | | | |
|---|---|---|---|
| C01F | 6 | C09K | 1 |
| C09D | 6 | C10L | 1 |
| C30B | 5 | C12N | 1 |
| B29B | 4 | C14C | 1 |
| E02B | 4 | C22B | 1 |
| A61K | 3 | C23C | 1 |
| B03C | 3 | D01F | 1 |
| B09B | 3 | D06P | 1 |
| C01G | 3 | F23G | 1 |
| C04B | 3 | G01N | 1 |
| B01F | 2 | G02B | 1 |
| C07B | 2 | H01B | 1 |
| C07K | 2 | | |

The frequency analysis above shows only simple count of IPCs, therefore it may not be enough to show how an IPC or a technology field is dominant in the division's patent pool. As a patent has multiple IPCs in many cases, it is relevant to perform a co-classification analysis. Fig.1 shows the network of co-classifications appearing in the patents of the division, and Fig. 2 presents the visual illustration of the network's betweenness centrality. In the Fig. 1, B01J is clearly in the center of the whole network, and has a dense network of linkages with other classes. In addition, B01J is still in the center of the Fig. 2, and it means that it is the closest node to all others. Considering the visual presentation of co-classification network and betweenness measure, it B01J is the dominant IPC, and the patents by Division A are mostly concentrated around the "chemical or physical processing" technology field.

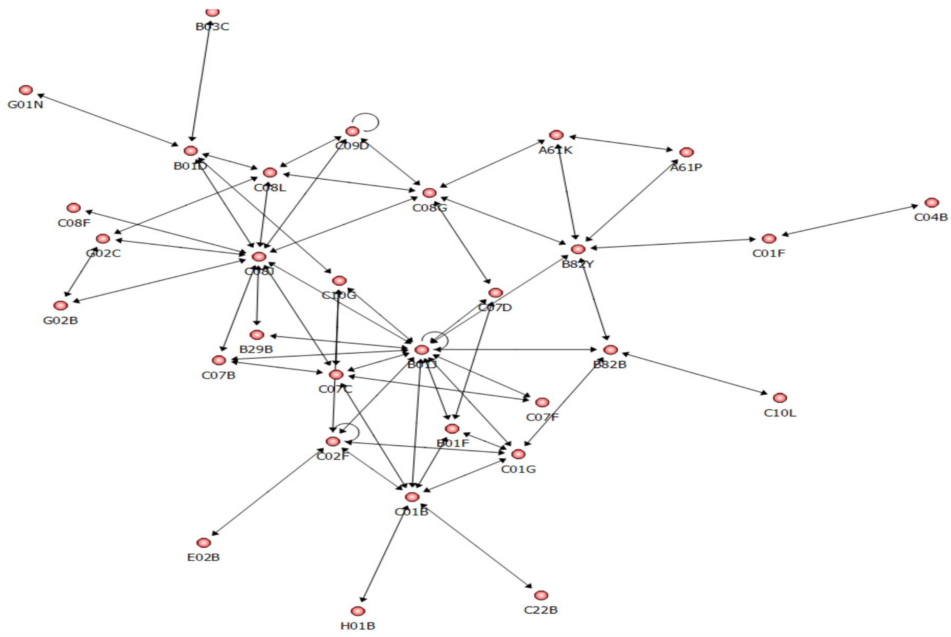


Fig. 1. Co-classification Network of Patents by the Division A

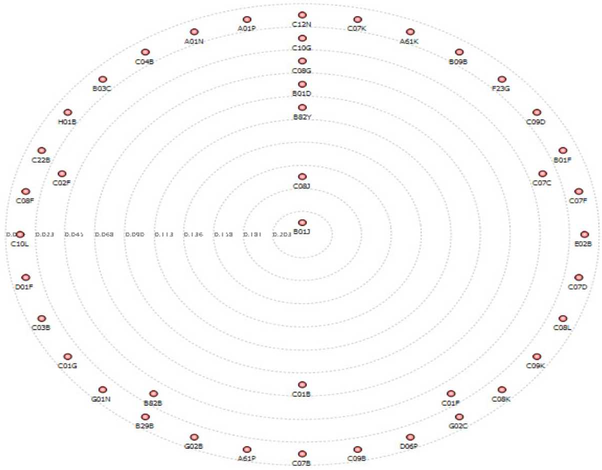


Fig. 2. Betweenness Centrality of the Network

### 3.2. *Sub-IPCs of Division A's Patents*

B01J was identified as the dominant IPC in the previous section, and we attempted to find sub-IPCs of the technology field. All IPCs that co-occur with B01J in the patents by the Division A were collected, and the closeness of the IPCs were measured as in the Table 2. While the closeness measure ranges from 0.52 to 0.6, the closeness of C01B, C07C, C08J, and B01F are slightly stronger than others. Considering the result of IPC analysis, the technology fields of the Division A are mostly about chemical or physical processes of non-metallic elements or compounds and acyclic or carbocyclic compounds; processing of organic compounds; and mixing processes (Table 3).

Table 2. Closeness from the Dominant IPC

| IPC | Closeness |
|---|---|
| B01J | 1 |
| C01B | 0.6 |
| C07C | 0.6 |
| C08J | 0.6 |
| B01F | 0.6 |
| C07B | 0.571429 |
| C01G | 0.571429 |
| B82Y | 0.545455 |
| C07D | 0.545455 |
| B82B | 0.545455 |
| B29B | 0.545455 |
| C10G | 0.521739 |
| C02F | 0.521739 |

Table 3. Descriptions of each IPC

| | | |
|---|---|---|
| B01J | | Chemical or physical processes or their relevant apparatus |
| | C01B | Non-metallic elements or their compounds |
| | C07C | Acyclic or carbocyclic compounds |
| | C08J | Working-up or general processes of compounding (of organic macromolecular compounds) |
| | B01F | Mixing (e.g. dissolving, emulsifying, and dispersing) |

### 3.3. *Forward Citation Analysis*

We searched for the Korean patents which citing the patents with co-classification of B01J and sub-IPCs, and collected the names of the applicants of the citing patents. Using the data of the applicants of citing patents and the co-classification (of B01J and sub-IPCs) of cited patents, we performed a 2-mode network analysis and measured degree-centralities to explore which co-classifications are significant in terms of forward citation. The results are summarized in Fig. 3 and Table 4 below.

Figure 3 illustrates which co-classifications are linked with (or cited by) which applicants. The applicants appear in the figure can be regarded in our study as potential users of technology. Some co-classifications have denser networks of linkages with many applicants than others have. These co-classifications may be the technology fields that are likely to be demanded by potential users, and therefore the possibilities of technology transfer are high.

The Table 4 shows co-classifications in terms of degree centralities. For instance, the degree centrality of B01J and C01B co-classification is the highest at 0.228829, and patents which have B01J and C01B are highly likely to be transferred to technology users. It is worth pay attention on that the order of co-classification in Table 4 is different from the order of sub-classes in Table 2. Whilst Table 2 was drawn from the network of IPCs in the Division A's patents, Table 4 was from the 2-mode network of co-classifications and applicants (potential users). The IPCs in the Table 2 show the major fields of patents by the Division A, whilst the Table 4 shows forward citation of technology fields in general. In other words, Table 2 shows what the Division A does, and Table 4 shows which technologies are likely to be transferred to users. Therefore, the comparative importance of technologies by Division A may be different from the comparative importance of technology users' demand. However, as almost all IPCs in Table 2 appear in Table 4, Division A seems to have been carrying out what potential users have been demanded.

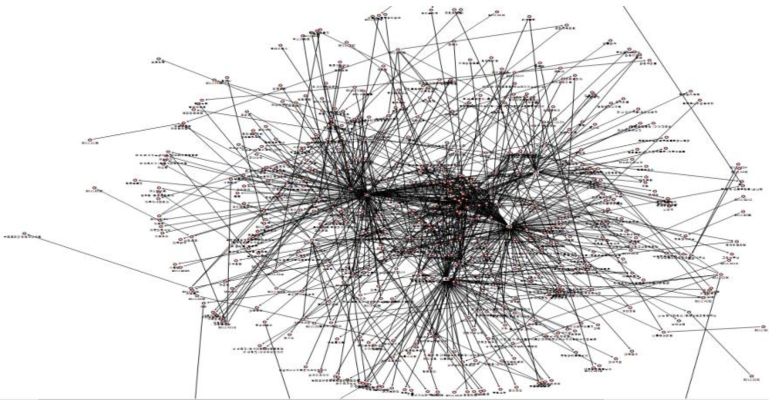

Fig. 3. 2-mode network of Cited Co-Classes and Citing Applicants

Table 4. Degree Centrality

| Co-classification | Degree Centrality |
|---|---|
| B01J & C01B | 0.228829 |
| B01J & B01D | 0.192793 |
| B01J & C01G | 0.111712 |
| B01J & C02F | 0.082883 |
| B01J & C07C | 0.077477 |
| B01J & B82B | 0.064865 |
| B01J & C10G | 0.045045 |
| B01J & H01L | 0.041441 |
| B01J & F01N | 0.037838 |
| B01J & H01M | 0.037838 |

## 3.4. Potential Users

Table 5 shows the names of organizations that were found in the forward citation analysis in the previous section. Among the co-classifications, Table 5 displays only 5 selected co-classifications for the purpose of presentation. There are 38 companies in B01J & C07C, 102 companies in B01J & C01B, 24 companies in B01J and C10G, 45 companies in B01J and C02F, and 58 companies in B01J and C01G

Table 5. List of Organizations Citing the Patents in the Co-class (Potential Users)

| Co-Class | Organizations that Citing the Co-Class Patent |
|---|---|
| B01J and C07C | Gutz, Kumho Petrochemical, Nideck, Dasol Technology, DSME, Duksan Hi-metal, Toshiba, Dongyang Technology Development, Robert Bosch, Mui ENG, Samsung SDI, Samsung Electronics, Samsung Heavy Industries, Samsung Total, Seoho Metal, CQV, IT & C, Aekyung Petrochemical, SK Energy, SK Chemical, SK Telecom, SK Hynix, LG Electronics, LG Chemicals, Otis Elevator, Yuseong Tech, W User Company, WinTech, EMW, Infraware, Ji-in Steel, KCI, Tera Semicon, P&B, Delphi Korea, Hanrim Lodex, Hyundai Steel, Hyundai Heavy Industries (Total 38) |
| B01J and C01B | Green ENE, Geukdong Engineering, Dongmyung Construction Engineering, Glovit, Kumho Mitsui Chemical, Kumho Petrochemical, Kia Motors, Hyundai Motors, Saram&Nanum, Wonil Industries, Nau Construction, Naco Engineering, Daelim Industries, Daesung Electric, Daewoo IS, DSME, The Boeing Company, Dekist, Delko Korea, Toray AMK, Toshiba Samsung Storage, City and Forest, Dongbu Hi-Tech, Donyang Carbon, Dongwoo Fine Chem, Dongwha Construction, DMBH, Digi Entertainment, Raonsecure, Rust Chemical, Loreal, Lumens, Macronics International Company, Muyung Amex, BLT, Samsung Display, Samsung Mobile Display, Samsung SDI, Samsung LED, Samsung Electric, Samsung Electronics, Samsung Heavy Industries, Samsung Total, Seoul Semiconductor, Semes, Seiko Instrument, Soft Pixel, Shinsung, FA, Hyundai Heavy Industries, etc. (Total 102 Companies) |
| B01J and C10G | Digital Zone, etc. (total 24 companies) |
| B01J and C02F | Green ENE, etc. (total 45 companies) |
| B01J and C01G | Dasol Technology, etc. (total 58 companies) |

### 3.5. *Verification of the Method*

Table 6 shows actual recipients of Division A's patents for the period of 2004-2013. Division A's patents in B01J class were transferred to 24 organizations. Among the cases, 11 were in B01J and C07C co-class, 5 were in B01J and C01B, and 8 were all others. The names of organizations are in the Table 5.

Table 6. Recipients of Technology Transfer from Division A (2004-2013)

| Co-classification | No. of Recipients | Names of Recipients |
|---|---|---|
| B01J and C07C | 11 | SK Energy, Hyundai Engineering, PNE, Kumho Petro-Chemicals, Hyundai Heavy Industries, SK Chemical, Samsung Petro-Chemical, KCI, Yeocheon NCC, Buheung Industries, Aekyung Petrochemical |
| B01J and C01B | 5 | E&G Tech, Hanchang Industries, Hyundai Heavy Industries, Buheung Industries, K Energy |
| B01J and C10G | 3 | SK Energy, Hyundai Engineering, SK Innovation |
| B01J and C02F | 2 | Febiane.com, Yuseong Tech |
| B01J and C01G | 1 | E&G Tech |
| B01J and B01D | 1 | Unknown |
| B01J and B82B | 1 | Unknown |

The comparison between Table 5 and 6 yields the names of organizations which appear in both tables. These organizations are those identified as "potential users of technology", and also actual recipient of Division A's technology. In the case of B01J and C07C, 5 companies including SK Energy, Kumho PetroChemicals, Hyundai Heavy Industries, SK Chemical, KCI, and Aekyung Petrochemical were actual recipients as well as potential users. In B01J and C10B, only 1 company (Hyundai Heavy Industries) was a recipient that can be found in the list of potential users. For other co-classifications, there was no company name that appears in both tables.

Table 7. Actual Recipients that can be found in the Potential Users List

| Co-classification | No. of Companies | Names of Recipients |
|---|---|---|
| B01J and C07C | 6 (out of 38) | SK Energy, Kumho Petrochemicals, Hyundai Heavy Industries, SK Chemical, KCI, Aekyung Petrochemical |
| B01J and C01B | 1 (out of 102) | Hyundai Heavy Industries |
| B01J and C10G | 0 | - |
| B01J and C02F | 0 | - |
| B01J and C01G | 0 | - |
| B01J and B01D | 0 | - |
| B01J and B82B | 0 | - |

### 3.6. *Discussion*

The results above partially support the idea that forward citation analysis can be used for identifying potential users of technology and may help technology transfer of public research institutes. For the co-classification of B01J and C07C, total 38 companies were found as potential users, and 6 among them were proved to be actual recipients of patents in the field. It can be seen a successful case of using the method for technology transfer. However, actual recipients could hardly be found in other co-classifications.

We suspect that there are a number of reasons for this result. Firstly, the characteristics of technologies may be a factor that should be considered. Some fields of technologies are mature, so the progress of technology may be incremental, cumulative, and sometimes predictable. In this case, patent citation in the past can be a good indicator for technology needs (or demand) in the future. Contrarily, some technology fields are characterized by rapid progress, radical changes, a wide variety of technological options, and low predictability. In this case, we suppose technological needs or demand at present or in the future may be different from the past, and it makes forecasting technological needs difficult.

Secondly, we suspect that there may be some effects from company size. As we can see in the Table 6, majority of success cases are very large companies. Large companies may have a huge stock of patents, and also have a wide variety of technological needs. Then, large companies may frequently appear in any kind of patent analysis just because they are large.

To sum up, our analysis was not enough to confirm the argument that patent citation in the past can be an indicator for technology needs in the future. In order to overcome the limitation of our study, there must be large scale research which considering technological characteristics and firm size effects.

## 4. Conclusion

The purpose of this study was to examine whether potential users of technology can be identified by patent citation analysis. Considering path dependence, patent citation reflects the technological needs. Once a firm cited a patent in the past, then it may be still in need of technology in the same field at present or in the future. Then, the firm is likely to be a recipient of technology transfer in the future. There have been a few studies that confirmed this view. However their approach was hard to implement in practice as they were based on keyword search for each patent. Therefore, we attempted to use IPC instead of keywords. By applying co-classification analysis, we tried to identify dominant IPC of the organization's technology. Then we explored applicants of patents that cited the patents in the dominant IPC and sub-classes. Our view was that the organizations found in this process can be potential users of technology.

To verify our view, we examined the patents and technology transfer cases of K Research Institute's Division A. The results show that our view was right for the co-classification of B01J and C07C. Actual recipients of patents in this field could be found in the list of potential users identified from our analysis. However, it was not possible to verify our argument for other classes. We suppose that the reasons may stem from technological characteristics and firm size effect. As our data come from a division in a single research institute, it was not possible to overcome the limitation. Therefore, we suggest that there should be further research utilizing large scale data and considering technological characteristics and firm size.

## Acknowledgements

This work was supported by the National Research Foundation of Korea Grant funded by the Korean Government(NRF-2014S1A5B8061859).

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